10/580713
IAP20 Rec'd PCT/PTO 25 MAY 2006

Specification

Igniter Device and Gas Generator

Technical Field

[0001]

The present invention relates to an igniter device used for a gas generator and to a gas generator used for operating a vehicle occupant protection system such as an automobile seatbelt pretensioner and the like.

Background Art

[0002]

A seatbelt pretensioner and an airbag are known as a safety system to protect a vehicle occupant from the shock in a car collision. The seatbelt pretensioner and the like are brought into action by a large amount of gas introduced from the gas generator, for the protection of the vehicle occupant. The gas generator includes an igniter device and gas generant and is structured so that when a car collision happens, the igniter device is brought into action to ignite and burn the gas generant, so as to generate the large amount of gas rapidly.

[0003]

An example of the conventional igniter device used for the gas generator is shown in FIG. 5, which is an igniter device 104 having a plug 107 formed of thermoplastic resin and the like and fitted in a cup 112 to seal an enhancer agent 103 in the cup 112. The plug 107 is provided with two electrode pins 108, 109 extending through it. The electrode pins 108, 109

are projected into an interior of the cup 112 and electrically connected with an electric bridge-circuit wire 110 at tip ends thereof. The electric bridge-circuit wire 110 is covered with a firing agent 111 contacting with the enhancer agent 103. The firing agent 111 has good ignition sensitivity so that it can be ignited by the heating of the electric bridge-circuit wire 110 to ignite the enhancer agent 103.

[0004]

The igniter device 104 is mounted to the gas generator, to allow an electric current to flow through it in accordance with collision signals from collision sensors, so as to heat the electric bridge-circuit wire 110. The electric bridge-circuit wire 110 heated ignites the firing agent 111 and in turn ignites and burns the enhancer agent 103. Then, the pressure and heat generated by the burning of the enhancer agent 103 causes the ignition and burning of the gas generant 101 and, then, the gas generated is spurted into the seatbelt pretensioner.

[0005]

Also, an example of the conventional gas generator for the seatbelt pretensioner is shown in FIG. 6. The gas generator 100 of FIG. 6 comprises the gas generant 101 that generates a large amount of gas when ignited, an igniter device 104 (Cf. FIG. 5) containing an enhancer agent 103 which is ignited by the passage of electric current through the igniter device, a cup 102 containing the gas generant 101, an igniter case 114 to cover the cup 112, a holder 106 to hold the igniter device 104 and the igniter case 114 concentrically and seal the gas generant 101 and the igniter device 104 in an inner space between the holder 106 and the cup 102, an O-ring 115

disposed in a gap between the igniter device 104 and the holder 106 to prevent infiltration of moisture from the gap therebetween, and a shorting clip 113 to keep two electrode pins 108, 109 standing from the igniter device 104 in a shorted state. Also, a sealant, not shown, is applied to the gap between the cup 102 and the holder 106, to prevent moisture infiltrating into the gap therebetween.

[0006]

It is should be noted here that the plug 107 is formed of thermoplastic resin. Specifically, synthetic resin, such as polybutylene terephthalate (PBT), nylon 6, and nylon 66, in which glass fibers and the like are mixed, is used for the plug 107 (Cf. Patent Document 1, for example).

[0007]

It is also proposed that thermosetting resin of unsaturated polyester resin and the like is used for the plug (Cf. Patent Document 2, for example).

[0008]

Patent Document 3 discloses a gas generator including an igniter device having a plug comprising an insulating supporting portion formed of epoxy resin, a cylindrical metal sleeve, and a molded sheath portion formed of thermoplastic resin.

[0009]

Patent Document 4 discloses an igniter device which has a plug comprising a solid body and a glass sheath and is sealed by epoxy resin.

[0010]

Patent Document 5 discloses a gas generator including an igniter device having a header (plug) formed of thermoplastic resin or

thermosetting resin of unsaturated polyester.

[0011]

Patent Document 6 discloses a gas generator including an igniter device having a header (plug) formed of glass-fiber-reinforced resin.

[0012]

Further, Patent Document 7 discloses a gas generator having a holder with two insertion holes for allowing two electrode pins to pass through respectively and an igniter device having a hermetic member corresponding to a plug formed of insulating resin.

[0013]

Patent Document 1: JP Publication (Publication No. 2003-25950) of JP Unexamined Patent Application (Page 4 and FIG. 4);

Patent Document 2: JP Publication (Publication No. 2002-90097) of JP Unexamined Patent Application (Page 5);

Patent Document 3: JP Publication (Publication No. 2000-108838) of JP Unexamined Patent Application (Page 5);

Patent Document 4: JP Publication (Publication No. 2000-241099) of JP Unexamined Patent Application (Pages 4 and 5);

Patent Document 5: Pamphlet of International Publication (Publication No. WO01/031281);

Patent Document 6: Pamphlet of International Publication (Publication No. WO01/031282); and

Patent Document 7: JP Publication (Publication No. 2000-292100) of JP Unexamined Patent Application (FIG. 1).

Disclosure of the Invention

Problems to be Solved by the Invention

[0014]

It is common in the conventional ignition device that the resin plug used for sealing the enhancer agent in the cup is formed of thermoplastic resin, as previously mentioned. The plug formed of thermoplastic resin has the possible problem that when the igniter device is incorporated in the gas generator for intended use and the gas generant is fired and burnt in the vehicle fire at the car collision or in the trial burn of the gas generator in an unexpected high-temperature state, the plug formed of thermoplastic resin may be softened so that the two electrode pins extending through the plug may be burst forth by the pressure of high-pressure gas in the gas generator. When the plug is increased in thickness, in order to prevent this possible situation, the igniter device is increased in size to that extent, so that the gas generator is increased in size or an amount of gas generant packed in the gas generator is reduced if the size of the gas generator cannot be increased any further. Further, in the case where the plug is produced to have the electrode pins and electrode-pin inserting portions which are formed of metal and sealed with glass, the parts cost comes high and the glass melting process is required for manufacturing the plug. As a result, the manufacturing cost comes high and resultantly the plug comes expensive.

[0015]

On the other hand, the plug formed of unsaturated polyester composition has the disadvantage of poorness in productivity, because a relatively long time is required for curing the unsaturated polyester

composition completely. It also has the disadvantage that when peroxide is used as a cure reaction initiator, the composition is dissolved easily due to the unstableness of peroxide, causing deterioration in workability.

[0016]

Also, the plug formed by a plurality of components has the problem with the sealing properties between the components. It also involves the disadvantage that the parts count is increased, involving time-consuming works in manufacturing.

[0017]

It is an object of the present invention to reduce the size of the igniter device by enhancing the strength of the plug under high temperature and thereby reducing thickness of the plug, without any significant reduction in productivity; to surely prevent the electrode pins being burst forth from the plug; to provide the igniter device that can ensure the sealing properties between the plug and the electrode pins; and to provide a gas generator using the same igniter device. It is another object of the present invention to produce the gas generator comprising the electrode pins and the holder which are integrally molded using thermosetting resin, or preferably epoxy resin.

Means for Solving the Problem

[0018]

The present invention provides an igniter device comprising a resistance heating element, gunpowder to be ignited by heat generation of the resistance heating element, electrode pins connected to the resistance heating element, and a plug for holding the electrode pins, wherein material

of the plug is a thermosetting resin.

[0019]

The igniter device of the present invention may be constructed so that it comprises a cup containing an enhancer agent, a plug, fitted in the cup, to seal the enhancer agent packed in the cup, two electrodes extending through the plug, an electric bridge-circuit wire interconnecting ends of the two electrode pins located in the cup, and a firing agent covering the electric bridge-circuit wire and contacting with the enhancer agent, and the plug is formed of a thermosetting resin.

[0020]

It is preferable in the igniter device of the present invention that the epoxy resin composition comprises an epoxy resin and a curing agent. Preferably, the epoxy resin composition contains 30-95weight% filler of the total epoxy resin composition. It is preferably that the filler comprises at least one of molten silica, crystallized silica, aluminum oxide, and calcium carbonate. It is preferable that the epoxy resin comprises at least one of bisphenol type epoxy resin, novolak type epoxy resin, biphenyl type epoxy resin, naphthalene type epoxy resin, alicyclic epoxy resin, and amines epoxy resin. It is preferable that the curing agent comprises at least one of phenol novolak resin, acid anhydride, and amines. Preferably, the epoxy resin composition comprises a curing accelerator. It is preferable that the plug has, at a portion thereof on the holder side, a stepped portion which is formed so that the portion thereof on the holder side is reduced in diameter.

[0021]

Also, the present invention provides a gas generator comprising a cup

packed with gas generant to generate gas by burning, an igniter device arranged in an interior of the cup, and a holder for holding the igniter device and the cup, the igniter device comprising a resistance heating element, gunpowder to be ignited by heat generation of the resistance heating element, electrode pins connected to the resistance heating element, and a plug for holding the electrode pins, wherein material of the plug is a thermosetting resin, and wherein the holder has insertion holes for allowing the electrode pins to extend through them, respectively.

[0022]

The gas generator of the present invention may have the igniter device of the present invention. The gas generator of the present invention may be constructed so that it comprises a second cup packed with gas generant to generate gas by burning, an igniter device arranged in an interior of the second cup and having a first cup containing an enhancer agent, and a holder for holding the igniter device and the second cup, the igniter device comprising a plug, fitted in the first cup, for sealing the enhancer agent in the first cup, and two electrode pins extending through the plug toward the holder, wherein the holder has two insertion holes for allowing the two electrode pins to extend through them, respectively, and wherein the plug is formed of thermosetting resin composition.

[0023]

It is preferable that root portions of the electrode pins extending from the plug are sheathed with skirt portions formed to be integral with the plug and the skirt portions are inserted in the insertion holes. It is preferable that the plug has, at a portion thereof on the holder side, a stepped portion

which is formed so that the portion thereof on the holder side is reduced in diameter. Preferably, the plug is formed of epoxy resin composition. It is preferable that a cross-section area of the two insertion holes is more than once to ten times or less a cross-section area of the electrode pins. Also, it is preferable that a sealing material for sealing a space between the holder and the plug is arranged near the stepped portion.

Effect of the Invention

[0024]

According to the igniter device of the present invention, since the plug is formed of thermosetting resin, the plug has a sufficient strength under high temperature and is resistant to softening in the high temperature state, thus enabling the electrode pins to be prevented from being dropped out from the plug. This can ensure the strength required for preventing the electrode pins from being burst forth even when the plug is reduced in thickness, thus allowing reduction in size of the igniter device to the extent corresponding to the reduction in thickness of the plug.

[0025]

In the gas generator of the present invention, the two electrode pins are inserted in the two small insertion holes formed in the holder, respectively. Due to this, even when the enhancer agent is burnt to put the second cup in a high-temperature and high-pressure state, since a greater part of the end face of the plug is abutted with and surely received by the holder, the two electrode pins are resistant to being burst forth from the holder. In addition, since the electrode pins are inserted in the insertion holes to be closely spaced from the holder, when static electricity flows in the

electric test, the static electricity is discharged and escaped from the space between part of the electrode pins around which neither the gunpowder nor the enhancer agent is arranged and the holder, to prevent the electric discharge that may cause the firing of the gunpowder and the enhance.

Best Mode for Carrying out the Invention

[0026]

As shown in FIG. 1, an igniter device 4 of the present invention comprises an enhancer agent 10, a first cup 11 for covering and containing the enhancer agent 10, a plug 13, partly fitted in the first cup 11, for sealing the enhancer agent 10 in the first cup 11, and two electrode pins 14, 15 extending through the plug 13 toward a holder 5. As shown in FIG. 1, the two electrode pins 14, 15 are electrically connected with each other at tip ends thereof on the first cup 11 side through a resistance heating element 16, and the resistance heating element 16 is covered with a firing agent 17 contacting with the enhancer agent 10. In short, the igniter device 4 is structured so that when electric current flows through the electrode pins 14, 15, the resistance heating element 16 can be heated to cause ignition of the firing agent 17 and in turn cause ignition and burning of the enhancer agent 10 which is in contact with the firing agent 17. In the ignition device 4 of the present invention, it is preferable that the use of the enhancer agent 10 is eliminated. In this variant, an amount of gunpowder of the firing agent 10 covering the resistance heating element 16 is adjusted so that the substantially same effect as the effect the ignition device with the enhancer agent 10 produces can be produced. It is further preferable in this variant that the first cup is eliminated. The method of covering the enhancer agent

for storage is not particularly limited to the use of the cup. As an alternative to the cup, coating resin over the enhancer agent may be used, for example.

[0027]

It is preferable that the materials used for the electrode pins 14, 15 include, iron, stainless steel, and alloys containing nickel.

The resistance heating element 16 includes the so-called electric bridge-circuit wire formed of metal such as, for example, nickel-chromium alloy, and platinum. The heaters (SCB) using the semiconductor manufacturing techniques are preferably used as the resistance heating element 16. Among others, the one using a reactive bridge is further preferably used as the resistance heating element.

[0028]

The first cup 11 has a closed-end cylindrical shape, having a flame leading portion 11a formed in the bottom for leading the heat current generated when the enhancer agent 10 in the first cup 11 is ignited to the gas generant 2 in the second cup 3 (FIG. 2). The flame leading portion 11a may have a notch which is called a score. Further, the first cup 11 has an engaging portion 11b which is formed at an end portion thereof on the opening side, to be engaged with the plug 13. The materials that may be used for forming the first cup 11 include, for example, plastic materials, such as polybutylene terephthalate, polyethylene terephthalate, NYLON 6, and NYLON 66.

[0029]

In the igniter device 4 of the present invention, when a specified

electric current flows between the electrode pins 14, 15, the resistance heating element 16 generates heat instantaneously. This heat generation allows the stable ignition of the firing agent and in turn allows the burning of the enhancer agent 10. As a result, an internal pressure of the first cup 11 rises, so that the bottom (the flame leading portion 11a) of the first cup 11 is burst. Then, the flame of the enhancer agent 10 spurts from the igniter device into the gas generator.

[0030]

The igniter device 4 of the present invention is usually produced taking the following steps: (1) the step of forming two electrode pins, (2) the step of forming the plug 13, (3) the step of forming welding surfaces on the electrode pins 14, 15, respectively, (4) the step of welding the resistance heating element 16 thereon, (5) the step of coating the resistance heating element 16 with the firing agent, (6) the step of contacting the firing agent with the enhancer agent 10, and (7) the step of fitting the plug 13 into the first cup 11.

[0031]

The gas generator using the igniter device 4 of the present invention is shown in FIG. 2. In this gas generator 1, the first cup 11 of the igniter device 4 is wholly covered by a closed-end igniter case (which is also called a squib case) 12 (FIG. 2). The igniter case 12 has a flame leading portion 12a, formed in the bottom, for leading the heat current to the gas generant 2 in the second cup 3. It also has a tapered flange portion 12b, formed at an end thereof on the opening side, for mounting the igniter case on the holder 5. This squib case 12 can be formed of metal, such as, for example, iron,

stainless steel, and aluminum, or synthetic resin, such as, for example, PBT (polybutylene terephthalate), and fluorocarbon resin. The first cup 11 containing the enhancer agent 10 is sheathed by the igniter case 12, so that the first cup 11 is held with an increased force to prevent from being burst before the internal pressure of the first cup 11 rises to a predetermined value when the enhancer agent 10 is ignited. Hence, the enhancer agent 10 can be burnt under a high pressure. As a result, a burning rate of the enhancer agent 10 is increased, so that an ignition delay of the gas generant 2 is decreased. The flame leading portion 11a of the first cup 11 and the flame leading portion 12a of the igniter case 12 are not necessarily formed in the bottoms thereof. Alternatively, one or more flame leading portions 11a and 12a may be formed in a circumferential side wall of the first cup 11 and in a circumferential side wall of the igniter case 12, respectively.

[0032]

As shown in FIG. 1, the plug 13 includes an inserting portion 13a inserted with an internal fit in the first cup 11, a large diameter portion 13b enlarged radially from a base end of the inserting portion 13a in a tapered form, and a small diameter portion 13c having a diameter smaller than that of the large diameter portion and extending continuously to the large diameter portion 13b through a stepped portion 13e. An intermediate portion 13f extending from the large diameter portion 13b to the small diameter portion 13c is in the form of a plane perpendicular to the extending-in-parallel portions of the electrode pins 14, 15. Thus, the plug 13 is configured so that the large diameter portion 13b can be reduced in thickness by forming the stepped portion 13e at a left end portion thereof

(an end thereof on the holder 5 side). The inserting portion 13a of the plug 13 is inserted with the internal fit within the first cup 11 and engaged with the engaging portion 11b to prevent the plug 13 from dropping out of the first cup 11. Preferably, the plug 13b has thickness in the range of 1.6mm-2mm.

[0033]

As shown in FIG. 2, a gasket 18 (sealing material) to prevent infiltration of moisture into the second cup 3 from between the plug 13 and the holder 5 is arranged at a location adjacent to the stepped portion 13e on the left side of the large diameter portion 13b. Instead of the gasket 18, a sealing agent in liquid form may be applied to therebetween. Further, the igniter case 12 and the plug 13 are fixed to the holder 5 by crimping an annular lug 5c of the holder 5 in the state of the tapered flange portion 12b of the igniter case 12 being in close contact with the tapered surface of the large diameter portion 13b.

[0034]

The two electrode pins 14, 15 extend through the plug 13 so that one end portions thereof project into the first cup 11 and the other end portions thereof extending toward the holder 5 extend through the holder 5. The end portions of the electrode pins 14, 15 projecting into the first cup 11 are electrically connected with each other via the resistance heating element 16. On the other hand, root portions of the electrode pins projecting from the plug 13 toward the holder 5 are sheathed with the truncated-cone-shaped skirt portions 13d projecting slightly from the small diameter portion 13c of the plug 13 toward the holder 5.

[0035]

In general, thermosetting resin is used as the material of the plug 13. Of the thermosetting resins, epoxy resin composition is preferably used for the plug 13 in terms of the thermosetting property and the moisture resistance. Preferably, the thermosetting resin composition comprises an epoxy resin and a curing agent. It is to be noted that although unsaturated polyester is a thermosetting resin having substantially the same fire resistance property as the epoxy resin composition, since it is inferior to the epoxy resin composition in adhesiveness to metal, it is not of preferable.

[0036]

The epoxy resins that may be used for the plug include, for example, polyfunctional epoxy resins which are glycidyl-etherified polyphenols compounds, polyfunctional epoxy resins which are various types of glycidyl-etherified novolak resins, alicyclic epoxy resins, aliphatic epoxy resins, heterocyclic epoxy resins, glycidyl esters epoxy resins, glycidyl amines epoxy resins, and epoxy resins obtained by the reaction of halogenated phenols with glycidyl.

[0037]

The polyfunctional epoxy resins which are glycidyl-etherified polyphenols compounds include, for example, phenol, cresol, bisphenol A, bisphenol F, bisphenol S, 4,4'-biphenyl phenol, tetramethyl bisphenol A, dimethyl bisphenol A, tetramethyl bisphenol F, dimethyl bisphenol F, tetramethyl bisphenol S, dimethyl bisphenol S, tetramethyl-4,4'-biphenol, dimethyl-4,4'-biphenylphenol, 1-(4-hydroxydiphenyl)-2-[4-(1,1-bis-(4-hydroxydiphenyl)ethyl)phenyl]propane, 2,2'-methylene-bis(4-methyl-6-

tert-butylphenol), 4,4'-butylidene-bis(3-methyl-6-tert-butylphenol), trishydroxyphenylmethane, resorcinol, hydroquinone, pyrogallol, phenols having a diisopropylidene skeleton, phenols having a fluorene skeleton, such as 1,1-di-4-hydroxyphenylfluorene, and epoxy resins which are glycidyl-etherified polyphenol compounds, such as phenolized polybutadiene.

[0038]

The polyfunctional epoxy resins which are various types of glycidyl-etherified novolak resins include, for example, novolak resins using as raw materials various types of phenols, such as phenol, cresols, ethyl phenols, butyl phenols, octyl phenols, bisphenol A, bisphenol F, bisphenol S, and naphthols, phenol novolak resin having a xylylene skeleton, phenol novolak resin having a dicyclopentadiene skeleton, phenol novolak resin having a biphenyl skeleton, and phenol novolak resin having a fluorene skeleton.

[0039]

The alicyclic epoxy resins include those having a cyclohexane skeleton, such as, for example, 3,4-epoxycyclohexylmethyl-3',4'-cyclohexylcarboxylate.

[0040]

The aliphatic epoxy resins include, for example, glycidyl ethers of polyhydric alcohol, such as 1,4-butamediol, 1,6-hexanediol, polyethylene glycol, polypropylene glycol, and pentaerythritol, xylene glycol derivative.

[0041]

The heterocyclic epoxy resins include, for example, those having a heterocyclic ring, such as an isocyanuric ring and a hydantoic ring.

[0042]

The glycidyl esters epoxy resins include, for example, epoxy resins comprising carboxylic acids, such as diglycidyl ester hexahydrophthalate and diglycidyl ester tetrahydrophthalate.

[0043]

The glycidyl amines epoxy resins include, for example, epoxy resins obtained by the reaction of amines with glycidyl, such as aniline, toluidine, p-phenylenediamine, m-phenylenediamine, diaminodiphenylmethane derivative, and diaminomethylbenzene derivative.

The epoxy resins obtained by the reaction of halogenated phenols with glycidyl include, for example, those, such as bromized bisphenol A, bromized bisphenol F, bromized bisphenol S, bromized phenol novolak, bromized cresol novolak, chloridized bisphenol S, chloridized bisphenol A, and bromophenol.

[0044]

No particular limitation is imposed on the use of those epoxy resins. Those epoxy resins may be properly selected in accordance with intended purposes and applications. Preferably, bisphenol type epoxy resin, novolak type epoxy resin, biphenyl type epoxy resin, naphthalene type epoxy resin, alicyclic epoxy resin, and amines epoxy resin are used. Bisphenol A type epoxy resin and novolak type epoxy resin are particularly preferable. Further, these epoxy resins may be selected according to the need of e.g. electric insulation, adhesion, water-resistance, dynamical strength, and workability and may be used in the form of a mixture of one or two or more materials.

[0045]

The curing agents include, for example, acid anhydride, amines, phenols, and imidazoles.

[0046]

The acid anhydrides include, for example, aromatic carboxylic anhydride, such as phthalic anhydride, trimellitic anhydride, pyromellitic anhydride, benzophenone tetracarboxylic anhydride, ethylene glycol anhydrous trimellitic acid, and biphenyl tetracarboxylic anhydride, aliphatic carboxylic anhydride, such as azelaic acid, sebacic acid, and dodecandioic acid, and alicyclic carboxylic anhydride, such as tetrahydrophthalic anhydride, hexahydrophthalic anhydride, nadic anhydride, chlorendic anhydride, and himic anhydride. The phthalic anhydrides include, for example, 4-methylhexahydrophthalic anhydride. The 4-methylhexahydrophthalic anhydride is particularly preferable.

[0047]

The amines include, for example, aromatic amines, such as diaminodiphenylmethane, diaminodiphenylsulfone, and diaminodiphenylether, aliphatic amines, and modified amines.

[0048]

The phenols include, for example, bisphenol A, tetrabrombisphenol A, bisphenol F, bisphenol S, 4,4'-biphenyl phenol, 2,2'-methylene-bis(4-methyl-6-tert-butylphenol), 2,2'-methylene-bis(4-ethyl-6-tert-butylphenol), 4,4'-butylidene-bis(3-methyl-6-tert-butylphenol), 1,1,3-tris(2-methyl-4-hydroxy-5-tert-butylphenol, trishydroxyphenylmethane, pyrogallol, phenols having a diisopropylidene

skeleton, phenols having a fluorene skeleton such as 1,1-di-4-hydroxyphenylfluorene, polyphenol compounds, such as phenolized polybutadiene, novolak resins using as raw materials various types of phenols such as phenol, cresols, ethyl phenols, butyl phenols, octyl phenols, bisphenol A, bromized bisphenol A, bisphenol F, bisphenol S, and naphthols, and various types of novolak resins, such as a phenol novolak resin having a xylylene skeleton, a phenol novolak resin having a dicyclopentadiene skeleton, and a phenol novolak resin having a fluorene skeleton.

[0049]

The imidazoles include, for example, various types of imidazoles, such as 2-methylimidazole, 2-phenylimidazole, 2-undecylimidazole, 2-heptadecylimidazole, 2-phenyl-4-methylimidazole, 1-benzyl-2-phenylimidazole, 1-benzyl-2-methylimidazole, 1-cyanoethyl-2-methylimidazole, 1-cyanoethyl-2-phenylimidazole, 1-cyanoethyl-2-undecylimidazole, 2,4-diamino-6(2'-methylimidazole (1'))ethyl-s-triazine, 2,4-diamino-6-(2'-undecylimidazole(1'))ethyl-s-triazine, 2,4-diamino-6-(2'-ethyl-4-methylimidazole(1'))ethyl-s-triazine, an adduct of 2,4-diamino-6-(2'-methylimidazole(1'))ethyl-s-triazine・isocyanuric acid, a 2:3 adduct of 2-methylimidazole isocyanuric acid, an adduct of 2-phenylimidazole isocyanuric acid, 2-phenyl-3,5-dihydroxymethylimidazole, 2-phenyl-4-hydroxymethyl-5- methylimidazole, and 1-cyanoethyl-2-phenyl-3,5-dicyanoethoxymethyl imidazole, and salts comprising the imidazoles and polyvalent carboxylic acid such as phthalic acid, isophthalic acid, telephthalic acid, trimellitic acid, pyromellitic acid, naphthalenedicarboxylic acid, maleic acid, and oxalic acid. These curing

agents are suitably selected according to the required property for the ignition squib structure or the required workability. Preferably, the curing agents are selected from the group consisting of the acid anhydrides, the phenol novolak resins, and the amines. The amount of curing agent used is determined so that an equivalent ratio of the curing agent to the thermosetting resin can fall in the range of from 0.3 to 2.0, preferably from 0.4 to 1.6, or further preferably from 0.5 to 1.3. Two or more curing agents may be mixed for use. Also, the imidazols may be used as a curing accelerator.

[0050]

The curing accelerators include, for example, various types of imidazoles, such as 2-methylimidazole, 2-phenylimidazole, 2-undecylimidazole, 2-heptadecylimidazole, 2-phenyl-4-methylimidazole, 1-benzyl-2-phenylimidazole, 1-benzyl-2-methylimidazole, 1-cyanoethyl-2-methylimidazole, 1-cyanoethyl-2-phenylimidazole, 1-cyanoethyl-2-undecylimidazole, 2,4-diamino-6(2'-methylimidazole(1'))ethyl-s-triazine, 2,4-diamino-6-(2'-undecylimidazole(1'))ethyl-s-triazine, 2,4-diamino-6-(2'-ethyl-4-methylimidazole(1'))ethyl-s-triazine, an adduct of 2,4-diamino-6-(2'-methylimidazole(1'))ethyl-s-triazine・isocyanuric acid, a 2:3 adduct of 2-methylimidazole isocyanuric acid, an adduct of 2-phenylimidazole isocyanuric acid, 2-phenyl-3,5-dihydroxymethylimidazole, 2-phenyl-4-hydroxymethyl-5- methylimidazole, and 1-cyanoethyl-2-phenyl-3,5-dicyanoethoxymethyl imidazole, salts comprising the imidazoles and polyvalent carboxylic acid, such as phthalic acid,

isophthalic acid, telephthalic acid, trimellitic acid, pyromellitic acid, naphthalenedicarboxylic acid, maleic acid, and oxalic acid, salts comprising amides such as dicyandiamide, diaza compounds, such as 1,8-diaza-bicyclo(5,4,0)undecene-7, and their phenols, the polyvalent carboxylic acids, or phosphinic acids, ammonium salts, such as tetrabutyl ammonium bromide, cetyltrimethyl ammonium bromide, and trioctylmethyl ammonium bromide, phosphinic acids, such as trioctylphosphine and tetraphenylphosphonium tetraphenylborate, phenols, such as 2,4,6-triaminomethylphenol, amine adducts, and microencapsulated curing accelerators in which those curing agents are encapsulated. These curing accelerators are suitably selected according to the required properties for the transparent resin composition, such as transparency, a curing rate, and working conditions. The amount of curing accelerator used is determined so that a ratio of the curing accelerator to the thermosetting resin can fall in the range of 0.1-5 parts by mass, or preferably in the order of 1 part by mass, per 100 parts by mass of the thermosetting resin.

[0051]

The fillers include, for example, various types of silica, such as fumed silica, and crystallized silica, silicon carbide, silicone nitride, boron nitride, calcium carbonate, magnesium carbonate, barium sulfate, calcium sulfate, mica, talc, clay, aluminum oxide, magnesium oxide, zirconium oxide, aluminum hydroxide, magnesium hydroxide, calcium silicate, aluminum silicate, lithium aluminum silicate, zirconium silicate, barium titanate, glass fiber, carbon fiber, molybdenum disulfide, and asbestos. Preferably used are fumed silica, crystallized silica, calcium carbonate, aluminum oxide,

aluminum hydroxide, and calcium silicate. Further preferably used are molten silica, crystallized silica, aluminum oxide, and calcium carbonate. These fillers are suitably selected according to the required performance and workability and the amount of filler used is determined so that a ratio of the filler to the total amount of thermosetting resin composition can fall in the range of 30-95weight%, preferably 40-90weight%, or further preferably 50-90weight%. These fillers may be used singly or in combination of two or more.

[0052]

Also, a colorant, a coupling agent, a leveling agent, and a lubricant, may be added to the epoxy resin composition for intended purposes.

[0053]

No particularly limitation is imposed on the colorant. The colorants include, for example, various types of organic coloring matters, such as phthalocyanine, azo, disazo, quinacridone, anthraquinone, flavanthrone, perinon, periren, dioxazine, condensed azo, and azomethine, and various types of inorganic coloring matters, such as titanium oxide, lead sulfate, chrome yellow, zinc yellow, chrome, vermillion, colcothar, cobalt violet, iron blue, ultramarine blue, carbon black, chrome green, chromic oxide green, and cobalt green.

[0054]

The coupling agents include, for example, silane coupling agents, such as 3-glycidoxypropyltrimethoxy silane, 3-glycidoxypropylmethyldimethoxy silane, 3-glycidoxypropylmethyldimethoxy silane, 2-(3,4-epoxycyclohexyl)ethyltrimethoxy silane,

N-(2-aminoethyl)3-aminopropylmethyldimethoxy silane, N-(2-aminoethyl)3-aminopropylmethyltrimethoxy silane, 3-aminopropyltriethoxy silane, 3-mercaptopropyltrimethoxy silane, vinyltrimethoxy silane, N-(2-vinylbenzylamino)ethyl)3-aminopropyltrimethoxy silane hydrochloride, 3-methacryloxypropyltrimethoxy silane, 3-chloropropylmethyldimethoxy silane, and 3-chloropropyltrimethoxy silane, titanium coupling agents, such as isopropyl(N-ethylaminoethylamino)titanate, isopropyltriisostearoyl titanate, titaniumdi(dioctylpyrophosphate)oxyacetate, tetraisopropyldi(dioctylphosphite)titanate, and neoalkoxytri(p-N-(β-aminoeethyl)aminophenyl)titanate, and zirconium or aluminum coupling agents, such as Zr-acetylacetonate, Zr-methacrylate, Zr-propionate, neoalkoxy zirconate, neoalkoxytrisneodecanoyl zirconate, neoalkoxytris(dodecanoyl) benzenesulfonyl zirconate, neoalkoxytris(ethylenediaminoethyl)zirconate, neoalkoxytris(m-aminophenyl)zirconate, ammonium zirconium carbonate, Al-acetylacetonate, Al-methacrylate, and Al-propionate. Preferably used is the silicon coupling agent. The use of the coupling agent can provide hardened material of excellent reliability in moisture resistance and less reduction in adhesion strength after moisture absorbent.

[0055]

The leveling agents include, for example, oligomers of the molecular weight in the range of 4,000-12,000 comprising acrylates, such as ethyl acrylate, butyl acrylate, and 2-ethylhexyl acrylate, epoxidated soybean fatty acid, epoxidated abiethyl alcohol, hydrogenerated ricinus, and titanic

coupling agent.

[0056]

The lubricants include, for example, hydrocarbon lubricants, such as paraffin wax, micro wax, and polyethylene wax, lubricants of higher fatty acid, such as lauric acid, myristic acid, palmitic acid, stearic acid, arachic acid, and behenic acid, lubricants of higher fatty acid amide, such as stearyl amide, palmithyl amide, oleyl amide, methylenebisstearo amide, and ethylenebisstearo amide, lubricants of higher fatty acid ester, such as hardened ricinus, butyl stearate, ethylene glycol monostearate, and pentaerythritol(mono-, di-, tri-, or tetra-)strearate, lubricants of alcohols, such as cetyl alcohol, stearyl alcohol, polyethylene glycol, and polyglycerol, metallic soaps of metallic salts, such as magnesium, calcium, cadmium, barium, zinc, and lead of lauric acid, myristic acid, palmitic acid, stearic acid, arachic acid, behenic acid, recinoleic acid, and naphthenic acid, and natural waxes, such as carnuba wax, candelilla wax, yellow beeswax, and montan wax.

[0057]

The epoxy resin composition is prepared in the following manner. When the components blended, such as the epoxy resin and the curing agent, and, if required, the curing accelerator, the filler, the colorant, the coupling agent, the leveling agent, and the lubricant, are in solid form, the components blended are mixed using a mixer, such as a Henschel mixer or a Nauter mixer, and, then, the mixture is kneaded at 80-120℃ using a kneader, an extruder, and a heating roller. After cooled, the resultant mixture is pulverized to powders, to thereby produce the thermosetting

resin composition. On the other hand, the components blended are in liquid form, they are mixed to be dispersed uniformly using a planetary mixer and the like, to thereby produce the thermosetting resin composition. If the viscosity of the liquid composition obtained is so high that the workability is deteriorated, then it may be adjusted to an adequate viscosity for the work by adding a solvent thereto. Also, the solid composition may be converted to a liquid form. In this case, the solid thermosetting resin composition obtained in the manner mentioned above may be dissolved in the solvent to prepare the liquid composition, or alternatively, the components to be blended may be dissolved in the solvent to prepare the liquid composition. Any particular limitation is imposed on the solvent used. As long as it is usually used as the solvent, any solvent may be used for preparation of the liquid composition. In the case where the thermosetting resin composition thus obtained is in solid form, it is common that after pelletized and then molded in a low pressure transfer molding machine, it is heated to 100-200℃ to be cured. On the other hand, in the case where the thermosetting resin composition is in liquid form, it is common that after subjected to a cast molding or dispensed, it is heated to 100-200℃ to be cured.

[0058]

In this connection, the epoxy resin mentioned above has a high glass transition point and a high strength under high temperature. Particularly preferably, the epoxy resin composition has a glass transition temperature higher than an autogenous ignition temperature of the gas generator. Further preferably, the epoxy resin composition has a higher glass

transition temperature (e.g. 180℃ or more) than an autogenous ignition temperature of the gas generant packed in the gas generator. By forming the plug 13 of this epoxy resin composition, there can be provided the following results: Even when the enhancer agent 10 is ignited to put the first cup 11 in a high-temperature and high-pressure state, the plug 13 can be prevented from being softened, thus making it hard for the electrode pins 14, 15 to be burst forth from the plug 13. Also, even when the plug 13 is reduced in thickness, the strength of the plug at the high temperature can be fully ensured. This can allow size reduction of the gas generator 1 to that extent or volume increase of the second cup 3, without changing the size, and as such can allow an increased amount of gas generant 2 packed. Hence, even when the gas generant (green propellants) which does not contain the smokeless gunpowder mentioned above, for which an increased amount of powder packed is required due to its less gas-generation efficiency, and produces a small amount of harmful gas components is used, the gas generator 1 need not be increased in size. Further, since the epoxy resin composition has good adhesiveness to the metal, the igniter device 4 of the present invention is improved in adhesion between the plug 13 and the electrode pins 14, 15, thus eliminating the need of using the sealing member for sealing the space therebetween. Also, when the holder 5 is formed of metal and is molded to be integral with the plug 13, the holder 5 can protect the first cup 11 containing the enhancer agent 10 against moisture infiltrating into the first cup 11 as much as possible without using the sealing member between the holder 5 and the plug 13.

[0059]

In FIG. 2, a shorting clip 19 to keep the two electrode pins 14, 15 a shorted state is fixed in the gas generator 1 using the igniter device 4 of the present invention. This shorting clip 19 serves to prevent operational error of the igniter deice 4 that may be caused by static electricity and the like.

[0060]

In the gas generator 1 using the igniter device 4 of the present invention, the holder 5 for holding the igniter device 4 has projections 5a formed around its outer circumference. The projections 5a are crimped onto a flange portion 3d of the second cup 3 to fix the second cup 3 to the holder 5. Also, the holder 5 has a concave, plug accommodating portion 5b formed at a portion thereof on the right side and an annular projection 5c projecting from a circumferential end of the accommodating portion 5b to the right side. The igniter case 12 and the plug 13 are fixed to the holder 5 by crimping, so that the annular projection 5c is put in abutment with the tapered flange portion 12b of the igniter case 12 in the state of the plug 13 being partly accommodated in the accommodating portion 5b.

[0061]

As previously mentioned, the plug 13 is formed to have the stepped portion 13e, and the corresponding accommodating portion 5b of the holder 5 to provide accommodation for the plug 13 comprises a large-diameter accommodating opening 21 for providing accommodation for the large diameter portion 13b of the plug 13 and a small- diameter accommodating opening 22 of the plug 13, extending continuously with the large-diameter accommodating hole 21, for providing accommodation for the small diameter

portion 13c of the plug 13. Since the large diameter portion 13b of the plug 13 is reduced in thickness by forming the stepped portion 13e in the plug 13, an engaging portion of the holder 5 to be engaged with the large diameter portion 13b of the plug 13 can be made larger in thickness than an engaging portion of the holder 5 to be engaged with the small diameter portion 13c of the same. This can ensure that the strength of the holder 5 is kept in the high pressure state when the gas generant 2 is burnt at the high temperature.

[0062]

It is preferable for the igniter device of the present invention that supporting members for sheathing the electrode pins are not included in the plug. In other words, the plug is molded into one piece from the epoxy resin. This can provide reduced number of components of the plug, as compared with the plug formed by a plurality of components including the supporting members. This can expect to provide reduced costs of the igniter device.

[0063]

The present invention can provide a compact gas generator suitably used for a seatbelt pretensioner for an automotive vehicle by using the igniter device. Description on the gas generator of the present invention will be given. The gas generator 1 shown in FIG. 2 comprises the second cup member 3 packed with the gas generant 2 to generate gas by the burning, the igniter device 4 having the first cup 11, arranged in the interior of the second cup 3, for containing the enhancer agent 10, the igniter case 12 having the flame leading holes 12a covering the first cup, and the holder 5

for holding the igniter case 12 and the first cup 11 by crimping the annular projection 5c onto the holder 5.

[0064]

As shown in FIGS. 2 and 4, the holder 5 has two insertion holes 23, 24 formed to extend parallel downwardly from a bottom end of the accommodating opening 22. The portions of the two electrode pins 14, 15 sheathed in the skirt portions 13d of the plug 13 are inserted in the two insertion holes 23, 24, respectively. It should be noted here that it is preferable that the two insertion holes 23, 24 have a certain level of small area within the range of allowing the electrode pins 14, 15 to be inserted therein. Specifically, it is preferable that the cross-section area of the insertion hole 23, 24 is more than once to ten times or less, or preferably in the range of twice to seven times, a cross-section area of the electrode pin 14, 15 extending through the insertion hole 23, 24. This construction of the holder 5 can provide the result that the bottom end face of the plug 13 is abutted with and received by a furthest end of the accommodating opening 22 of the holder 5. Further, since the insertion holes 23, 24 for the electrode pins 14, 15 to extend through them are reduced in area, as compared with those of the conventional igniter device 4, the electrode pins 14, 15 are prevented from being burst forth from the holder 5. Also, although the electrode pins 14, 15 are inserted in the insertion holes 23, 24 to be closely spaced from the holder 5, since the plug 13 is provided with the skirt portions 13d, when static electricity flows in the electric test, the static electricity can be escaped from the space between part of the electrode pins 14, 15 around which neither the gunpowder nor the enhancer is arranged

and the insertion holes 23, 24 of the holder 5, to prevent the electric discharge that may cause the firing of the gunpowder and the enhance.

[0065]

The holder 5 may be formed of metals such as, for example, aluminum, iron, and stainless steel. Preferably, the holder 5 is formed of aluminum in terms of easiness for molding, because the holder 5 is required to form the insertion holes 23, 24, the accommodating openings 21, 22, and the like therein.

[0066]

The gas generant 2 is packed in the second cup case 3 in the state of being in direct contact with the inner periphery of the second cup case 3, without any intermediary of filter and/or coolant. The gas generants that may preferably be used include a gas generant comprising a nitorogen-containing organic compound as a fuel component, an inorganic compound as an oxidizing agent component, and at least one additive. Specifically, the fuel components that may be used include at least one material selected from the group consisting of aminotetrazole, guanidine nitrate, and nitroguanidine. The oxidizing agent components that may be used include at least one material selected from the group consisting of strontium nitrate, ammonium nitrate, potassium nitrate, ammonium perchlorate, and potassium perchlorate. The additives that may be used include molybdenum trioxide which is an autoignition catalyst. In addition to these, a binder and the like can also be cited as the additive to be added to the gas generant. The binders that may be used include at least one material selected from the group consisting of guar gum, methyl cellulose,

carboxymethyl cellulose, water-soluble cellulose ether, and polyethylene glycol. Gas generant comprising 5-aminotetrazole and guanidine nitrate as the fuel component, strontium nitrate and ammonium perchlorate as the oxidizing agent component, molybdenum trioxide as the autoignition catalyst, and guar gum as the binder can be cited as a preferable gas generant. Further, gas generant comprising 10-30mass% 5-aminotetrazole and 15-35masst% guanidine nitrate as the fuel component, 10-35mass% strontium nitrate and 15-35masst% ammonium perchlorate as the oxidizing agent component, 1-10masst% molybdenum trioxide as the autoignition catalyst, and 1-10mass% guar gum can be cited as a further preferable gas generant. The gas generant used in the present invention may be molded, for example, in a desirable shape to be packed in the seatbelt pretensioner and the like. No particular limitation is imposed on the shape of the molded gas generant. The gas generant may be molded in a columnar shape or a pellet-like shape. Specifically, after water or an organic solvent is added to the gas generator in accordance with types of (a) 0.25%-5% cationic binder, (b) 0.25%-5% anionic binder, (c) a fuel, (d) an oxidizing agent, (e) a fuel adjusting agent, and the like, the mixture is mixed uniformly and kneaded. Then, the resultant mixture is molded into columnar molded products by the extrusion molding process and the cutting process or is formed into pellets by using a tableting machine and the like.

[0067]

The second cup 3 includes a large-diameter cylindrical portion 3a and a closed-end cylindrical portion 3b having two planate side surfaces which are continuous to the right side of the cylindrical portion 3a and parallel

with each other. As shown in FIG. 3, six notches 3c are formed in the bottom of the closed-end cylindrical portion 3b to extend radially from the center. When the gas generant 2 packed in the second cup 3 is burnt to thereby generate a high-temperature and high-pressure gas, the notches 3c are burst open by the pressure of the generated gas and then the gas is discharged directly to the seatbelt pretensioner not shown. The second cup 3 has the flange portion 3d formed at an end portion thereof on the opening side (the bottom side as viewed in FIG. 2) for the fixture to the holder 5, as mentioned later. The materials that may be used for forming the second cup 3 include metals, such as, for example, stainless steel, iron, and aluminum.

[0068]

Now, operation of the gas generator 1 mentioned above will be described. When automobile collision is detected by a collision sensor, not shown, the electric current passes through the two electrode pins 14, 15. Then, the resistance heating element 16 connected to the electrode pins 14, 15 generates heat and thereby the firing agent 17 is ignited. Sequentially, the ignition of the firing agent 17 causes the ignition and burning of the enhancer agent 10. As the burning of the enhancer agent 10 proceeds, the interior of the first cup 11 of the igniter device 4 is put in the high-temperature and high-pressure state. According to the present invention, since the first cup 11 is sheathed with and reinforced by the igniter case 12, as shown in FIG. 2, the first cup 11 is prevented from being expanded and burst before the enhancer agent 10 is fully burnt. Also, since the two electrode pins 14, 15 are inserted in the two small insertion holes 23,

24 formed in the holder 5, respectively, the two electrode pins 14, 15 are resistant to being burst forth from the holder 5 even in the high temperature and high pressure state of the first cup 11.

[0069]

When the burning of the enhancer agent 10 proceeds, causing the first cup 11 to rise up to a high temperature and a predetermined high pressure, the high-temperature and high-pressure flame of the enhancer agent 10 is spouted to the gas generant 2 in the second cup 3 at a stroke through the flame leading portion 11a and the flame leading holes 12a to ignite the gas generant 2. At this time, the igniter case 12, which is fixed to the holder 5 by crimping, is prevented from being burst forth toward the gas generant 2.

[0070]

Sequentially, the gas generant 2 is burnt and thereby the pressure of the second cup 3 rises up sharply by the gas generated instantaneously in the second cup 3 to cause the notches 3c formed in the second cup 3 to burst. Then, the high-temperature and high-pressure gas is introduced directly to the seatbelt pretensioner, not shown, to bring the seatbelt pretensioner into operation.

[0071]

According to the igniter device 4 of this embodiment thus constructed, since the plug 13 is formed of thermosetting resin, the plug 13 is resistant to softening in the high temperature state, so that an increased strength is provided for the plug 13 under high temperature. Also, since the plug 13 is resistant to softening in the high temperature state, the electrode pins 14, 15 are prevented from being dropped out from the plug 13. Also, even

when the plug 13 is reduced in thickness, since the strength required for preventing the electrode pins 14, 15 from being burst forth can be ensured, the igniter device 4 can be reduced in size to the extent corresponding to the reduction in thickness of the plug 13. Or, the second cup 3 can be increased in volume, thus allowing an increased amount of gas generant 2 packed. Further, since the igniter device is formed of the epoxy resin composition having good adhesiveness to the metal, the infiltration of moisture into the first cup 11 from between the electrode pins 14, 15 and the plug 13 can be prevented, thus providing excellent moisture resistance. In addition, since the electrode pins 14, 15 are integrally molded using the epoxy resin composition, an improved seal can be provided between the plug 13 and the electrode pins 14, 15 without any need of their supporting members. Besides, the parts count of the igniter device 4 can be reduced.

[0072]

It is particularly preferable that epoxy resin composition is used as the thermosetting resin composition. This is because since the epoxy resin composition, which comprises the epoxy resin having a high glass transition point and the curing agent, has good adhesiveness to metal, when the plug 13 is assembled in the gas generator 1, improved adhesion between the plug 13 and the electrode pins 14, 15 can be provided to surely protect the cup packed with the gas generant against infiltration of moisture into the cup.

[0073]

Further, the plug 13 is formed to have, at an end portion thereof on the holder 5 side, the stepped portion 13e to provide a decreased diameter for the end portion thereof on the holder 5 side. Since the plug 13 has, at its

portion on the holder 5 side, the decreased diameter formed by the stepped portion 13e, the holder 5 can be formed to have a larger thickness by that extent at its engaging portion to be engaged with the large-diameter portion 13b of the plug 13 than at its engaging portion to be engaged with the small-diameter portion 13c of the plug 13. This can ensure that the strength of the holder 5 is kept in the high-temperature and high-pressure state when the gas generant 2 is burnt.

[0074]

According to the gas generator 1 of this embodiment thus constructed, the two electrode pins 14, 15 are inserted in the two small insertion holes 23, 24 formed in the holder 5, respectively. Due to this, even when the enhancer agent 10 is burnt to put the second cup 3 in a high-temperature and high-pressure state, since a greater part of the end face of the plug 13b is abutted with and surely received by the holder 5, the two electrode pins 14, 15 are resistant to being burst forth from the holder 5. In addition, since the electrode pins 14, 15 are inserted in the insertion holes 23, 24 to be closely spaced from the holder 5, when static electricity flows in the electric test, the static electricity is discharged and escaped from the space between part of the electrode pins 14, 15 around which neither the gunpowder nor the enhancer is arranged and the insertion holes 23, 24 of the holder, to prevent the electric discharge that may cause the firing of the gunpowder and the enhancer agent.

[0075]

The root portions of the electrode pins 14, 15 extending from the plug 13 are sheathed in the skirt portions 13d, 13g integrally formed with the

plug 13, and the skirt portions 13d, 13g are inserted in the insertion holes 23, 24, respectively. By virtue of this, when the electrode pins 14, 15 are inserted in the insertion holes 23, 24, respectively, the fit between the skirt portions 13d, 13g and their respective insertion holes 23, 24 can be insured to minimize rattle of the plug 13 and also provide electrical insulation between the electrode pins 14, 15 and the holder 5 reliably.

[0076]

Also, the cross-section area of the insertion hole 23, 24 is more than once to ten times or less the cross-section area of the electrode pin 14, 15, This can provide the results that even when the holder 5 is formed of metal, the short circuit in the electrode pins 14, 15 can be prevented and that even when the resin plug forming the squib is softened at the ignition in the high temperature state, the electrode pins 14, 15 are prevented from being burst forth from the holder 5

[0077]

Further, since the sealing material to seal the space between the holder 5 and the plug 13 is arranged near the stepped portion 13e, the second cup 3 in which the enhancer agent 10 is shielded can be reliably protected against infiltration of moisture into it from the space between the holder 5 and the plug 13. Further, it is preferable that a holder portion is formed of metal and also the holder portion and the plug 13 are integrally molded from the epoxy resin composition, because this construction can provide so good adhesion between the metal portion and the resin portion that the need of the sealing material can be eliminated.

[0078]

Although the embodiment wherein the holder 5 and the plug 13 having the electrode pins 14, 15 are formed separately from each other has been illustrated above, the holder 5 and the electrode pins 14, 15 may be integrally molded from the epoxy resin composition. In this variant, the parts count can be reduced and thereby the manufacturing costs can be reduced.

Examples

[0079]

The present invention is explained below concretely with reference to Examples but is not limited to these Examples.

[0080]

Example of Igniter Device Used in the Present Invention

Example 1

The plug of the igniter device according to the present invention was molded by a so-called cast molding process. Specifically, after epoxy resin composition {(bis-phenol A type epoxy resin and a curing agent (4-methylhexahydrophthalic anhydride): Trade Name; KAYATORON ML-6650N available from Nippon Kayaku Co., Ltd.} was mixed, the mixture was poured into a mold and then cured. The plug was provided with metal pins. Before the plug was molded, the mold was drizzled with a mold release agent, first, and, then, the metal pins were put in the mold. Then, the resin composition was prepared. In this preparation process, the epoxy resin was previously heated to about 80℃ and the curing agent was previously heated to about 60℃. Then, after the epoxy resin and the curing agent were weighed and mixed in the proportion of 100: 100, they

were fully agitated. During the agitation, a large amount of air bubbles were produced in the epoxy resin composition of liquid form produced by mixing the bis-phenol A type epoxy resin and the curing agent. Due to this, the mixture was defoamed at 70-80℃ for about 10-15 minutes by using a vacuum defoaming machine, during which the mold in which the metal pins were put in place was preheated. After completion of the defoaming process, the epoxy resin composition in liquid form was transferred into a syringe and then injected in the mold using a dispenser, while it was warmed to about 50℃ by using a heater. After injected in the mold, the epoxy resin composition was defoamed again. Then, it was put in a high temperature oven of 100℃ for three hours and then put in the high temperature oven of 140℃ for three hours, to be cured. After the epoxy resin composition was cured, the mold was taken out from the high temperature oven and then the molded plug was taken out from the mold. Then, burrs were eliminated from the molded plug, if any. The plug was produced in the manner mentioned above. Then, after a resistance welding of the resistance heating element and a molding of the firing agent were performed in accordance with test requirements, the cup packed with the enhancer agent was set in place. The igniter device used in the present invention was completed in the manner mentioned above.

[0081]

Example of Gas Generator of the Present Invention

Example 2

The igniter case was assembled in the plug of the igniter device produced in Example 1 and then this assembly was assembled in the

aluminum holder to which sealing material had been applied. Then, after smokeless gunpowder (gas generant) was packed in the second cup, the second cup was fixed by crimping to the holder building the igniter device therein.

[0082]

A flammability test, a pressure proof test, and a humidity test were performed using the gas generator of the present invention, to confirm the effects of the gas generator of the present invention. The gas generator of the present invention having the plug of the igniter device formed of the epoxy resin composition was used in those tests. On the other hand, for comparison purposes, the gas generator shown in FIG. 6 having the plug of the igniter device shown in FIG. 5 formed of PBT resin (polybutylene terephthalate) and the one formed of unsaturated polyester were prepared for those tests. The components of the gas generant used in the tests comprised nitroguanidine, ammonium perchlorate, strontium nitrate, binder, and kaolin.

[0083]

Flammability test

Test Example 1

First, reference is made to the flammability test. In this test, a cylindrical jig having in a bottom thereof a gas discharge hole of 1mm in diameter and having an inner volume of about 10cc, and a propane burner used for heating the jig were used. The gas generator was inserted in the interior of the jig. In the flammability test, the jig was set on a base, and the propane burner was set directly below it. The distance between a tip

end of a nozzle of the propane burner and a bottom of the jig was set to be 400mm and the height of the flame from the propane burner was set to be 600mm by eye. The flammability test was carried out after the heating was started using the propane burner until the gas generant was ignited to thereby generate gases. In this test, the ignition was confirmed from an explosion one heard. Specifications of the gas generators used for this flammability test and the results are shown in TABLE 1 below.

[0084]

[TABLE 1]

Amount of smokeless gunpowder (mg)	Material of plug of igniter device	Results
1,000	Epoxy resin composition	Resin member was not broken
1,100	Epoxy resin composition	Resin member was not broken
1,200	Epoxy resin composition	Resin member was not broken
1,000	PBT resin composition	Resin member was not broken
1,100	PBT resin composition	Resin member was broken
1,200	PBT resin composition	Resin member was broken
1,000	Unsaturated polyester	Resin member was not broken
1,100	Unsaturated polyester	Resin member was not broken
1,200	Unsaturated polyester	Resin member was not broken

[0085]

It can be seen from TABLE 1 that in the gas generator incorporating therein the igniter device having the plug formed of PBT resin, when an amount of smokeless gunpowder used was 1,000mg, the PBT resin member

was not broken, but when the amount of smokeless gunpowder used were 1,100mg and 1,200mg, the PBT resin member was broken. In the gas generator incorporating therein the igniter device having the plug formed of unsaturated polyester, when the amount of smokeless gunpowder used were 1,000mg, 1,100mg, and 1,200mg, the unsaturated polyester resin member was not broken. On the other hand, in the gas generator incorporating therein the igniter device having the plug formed of epoxy resin composition, when the amount of smokeless gunpowder used were 1,000mg, 1,100mg, and 1,200mg, the epoxy resin member was not broken. It were found from these that the gas generator of the present invention incorporating the igniter device having the plug formed of the epoxy resin composition or the unsaturated polyester has an advantage in strength in the high temperature state over the gas generator incorporating the igniter device having the plug formed of the PBT resin.

[0086]

Pressure Proof Test

Example 2

Second, reference is made to the pressure proof test. In this test, three different types of gas generators were prepared. One was a gas generator wherein an igniter device having a plug formed of the commonly used PBT resin was assembled in a holder and a cup was fixed thereto by crimping. Another one was a gas generator wherein the plug of the igniter device of the present invention was molded and assembled in an igniter case as described above, the resulting assembly was assembled in an aluminum holder to which sealing material was applied, and a cup member was fixed

thereto by crimping. Still another one was a gas generator wherein an igniter device having a plug formed of unsaturated polyester was assembled in the holder and then a cup member was fixed thereto by crimping. The gas generant was not packed in any of these gas generators. These gas generators were subjected to the pressure proof test. In the pressure proof test, each of these gas generators was set on a jig having an inner volume of 3.5cc, first. Then, after the jig is filled with oil, hydraulic pressure was put on the gas generator gradually until the gas generator was broken, and the pressure at which the gas generator was burst was measured. The results obtained in this pressure proof test are shown in TABLE 2.

[0087]

[TABLE 2]

Material of plug of igniter device	Length of plug (mm)	Measured pressure value (MPa)	Occurrence of burst
PBT resin composition	3.6	150	Burst
Epoxy resin composition	2.9	189	Not burst
Unsaturated polyester	2.9	185	Not burst

[0088]

As seen from TABLE 2, in the conventional gas generator incorporating therein the igniter device having the plug formed of the PBT resin, the resin member was burst at 150MPa. In contrast to this, the gas generator of the present invention incorporating therein the igniter device having the plug formed of the epoxy resin composition, the resin member was not burst although the pressure put thereon rose up to 189MPa. Also,

the gas generator of the present invention incorporating therein the igniter device having the plug formed of the unsaturated polyester, the resin member was not burst although the pressure put thereon rose up to 185MPa. In addition, although the gas generator of the present invention incorporating therein the igniter device having the plug formed of the epoxy resin composition or unsaturated polyester and having a length of 2.9mm was shorter in length of the resin member by 0.7mm than the conventional gas generator incorporating therein the igniter device having the plug formed of the PBT resin and having a length of 3.6mm, the results were that the gas generator of the present invention had an advantage in strength over the conventional gas generator.

[0089]

Humidity test

Example 3

Further, reference is made to the humidity test. In this test, three different types of gas generators were prepared. One was a gas generator wherein an igniter device having a plug formed of the commonly used PBT resin was assembled in a holder through an O-ring and a cup was filled with gas generant and fixed to the holder by crimping. Another one was a gas generator of the present invention wherein the holder and the electrode pins were integrally molded using the epoxy resin composition and a cup was filled with gas generant and fixed to the holder by crimping. Still another one was a gas generator wherein the holder and the electrode pins were integrally molded using the unsaturated polyester and a cup was filled with gas generant and fixed to the holder by crimping. An amount of gas

generant packed was 1g. These three gas generators were subjected to the humidity test. The test conditions were so set that temperature was 85℃, humidity was 85%, and test time was 410 hours. After a sample was taken out from an environmental test machine, the gas generant was taken out from the gas generator, so that the moisture absorption amount was measured. The test results in this test are shown in TABLE 3.

[0090]

[TABLE 3]

Specification of gas generator	Moisture absorption amount (%)
Sealing structure using O-ring (Conventional)	0.41
Sealing structure using adhesion of epoxy resin	0.16
Sealing structure using adhesion of unsaturated polyester	0.53

[0091]

As seen from TABLE 3, in the conventional sealing structure using an O-ring, when measured under the atmosphere of temperature of 85℃ and humidity of 85% for 410 hours, the amount of moisture absorption of the gas generant was 0.41%. In contrast, in the sealing structure of the present invention using the adhesion of epoxy resin, the amount of moisture absorption of the gas generant was 0.16% and in the sealing structure of the present invention using the adhesion of unsaturated polyester, the amount of moisture absorption of the gas generant was 0.53%. It was found from these that the moisture absorption resistance of the gas generator of the present invention having the sealing structure wherein the holder and the

electrode pins were allowed to adhere to each other using the epoxy resin composition was 2.6 times or more as high as that of the conventional gas generator having the sealing structure using the O-ring. It was also found that the moisture absorption resistance of the gas generator of the present invention having the sealing structure wherein the holder and the electrode pins were allowed to adhere to each other using the epoxy resin composition was 3.3 times or more as high as that of the gas generator of the present invention having the sealing structure wherein the holder and the electrode pins were allowed to adhere to each other using the epoxy resin.

Brief Description of the Drawings

[0092]

FIG. 1 is a sectional view of an igniter device used in the present invention, taken along line III-III of FIG. 2;

FIG. 2 is a sectional view of a gas generator according to an embodiment of the present invention;

FIG. 3 is a view of a bottom portion of a second cup of the gas generator of FIG. 2;

FIG. 4 is a sectional view taken along line VI-VI of FIG. 2;

FIG. 5 is a sectional view of a conventional igniter device; and

FIG. 6 is a sectional view of a conventional gas generator.

Explanations of letters and numerals

[0093]

1 Gas generator

2 Gas generant

3 Second cup

3a Cylindrical portion

3b Closed-end cylindrical portion

3c Notch

3d Flange portion

4 Igniter device

5 Holder

5a Projection

5b Accommodating portion

5c Annular projection

10 Enhancer agent

11 First cup

11a Flame leading portion

11b Engaging portion

12 Igniter case

12a Flame leading hole

12b Flange portion

13 Plug

13b Large diameter portion

13c Small diameter portion

13a Insertion portion

13e Stepped portion

13d Skirt portion

13f Intermediate portion

14 Electrode pin

15 Electrode pin

16 Resistance heating element

17 Firing agent

18 Gasket

19 Shorting clip

21 Accommodating opening

22 Accommodating opening

23 Insertion hole

24 Insertion hole